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**Biodiversity surveys of Bugoma forest reserve, smaller central forest
reserves, and corridor forests south of Bugoma**

Plumptre, A ; Akwetaireho, S ; Hänni, D C ; Leal, M ; Mutungire, N ; Kyamanywa, J ; Tumuhameye, D
; Ayebale, J ; Isoke, S

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BIODIVERSITY SURVEYS OF BUGOMA FOREST RESERVE, SMALLER CENTRAL FOREST RESERVES, AND CORRIDOR FORESTS SOUTH OF BUGOMA.

Project number: UG0031.01

Project title: Conservation of Biodiversity in the Albertine Rift Forests of Uganda

Andrew Plumptre, Simon Akwetaireho, Daniel C. Hänni, Miguel Leal, Nabert Mutungire, Julius Kyamanywa, Dennis Tumuhamy, Johnson Ayebale and Sam Isoke.

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1.0 Executive Summary

This report summarises six months of biodiversity surveys made in 2010 in the Bugoma Central Forest Reserve (CFR) and the smaller CFRs and private forests to the south and south west of Bugoma CFR (Corridor forests). The surveys were made as part of the UNDP/GEF project for the Conservation of Biodiversity in the Albertine Rift Forests of Uganda which is managed and implemented by the World Wide Fund for Nature (WWF). The Wildlife Conservation Society (WCS) survey teams worked with many private land owners, the National Forest Authority and the Jane Goodall Institute to undertake these surveys and we are very grateful for their support and participation.

Three main taxa were surveyed: large and medium sized mammals; birds and trees/shrubs. Transect surveys of large mammals and birds were made in Bugoma and Kagombe CFRs while randomly allocated points were visited for tree/shrub plots and point counts of birds in the corridor forests. Recce walks were also used to assess the distribution of large and medium sized mammals in the corridor forests together with camera traps.

Many large and medium sized mammal species still occur in the corridor forests including chimpanzees, redbellied, baboons, vervets and black and white colobus monkeys, golden cats, side-striped jackals, bushbucks, Weyn's and blue duikers, bushpigs, and African civets. Elephants were still found in Bugoma and Kagombe CFR as they had been in surveys made in 1999. Primate densities were similar to those found in 1999 in Bugoma CFR with a significant increase in black and white colobus monkeys. In Kagombe CFR there was also a significant increase in these colobus monkeys but probably a decrease in chimpanzee numbers. Golden cats and side-striped jackals were reported using the corridor forests and the jackals were captured on camera traps.

Many bird species that probably require the corridors to link populations in the larger forest blocks were also found in these corridors, particularly the hornbills and tauracos. A few forest raptors were observed in the corridors but not many. Threatened bird species were only found in the larger blocks of forest such as Bugoma and Kagombe CFR. A total of 194 bird species were recorded during these surveys, nearly 20% of Uganda's total species number. Comparisons with point counts made in Bugoma in 2003 indicated that many of the more common species found in the forest have declined significantly in density but why this is so is not known.

199 tree and shrub species were recorded in these surveys also with Bugoma CFR being significantly richer in species than the corridor forests. Carbon measurements in 20m radius circular plots also showed that Bugoma contained significantly more carbon than the corridor forests, although the centre of the small CFRs to the south of Bugoma contained significant amounts of carbon also. It is estimated that about 500 tonnes of CO₂ per hectare occurs in these forests.

The conclusion of the surveys is that the corridor forests south of Bugoma are relatively rich in species and have a conservation value in terms of both species richness as well as providing the function of linking larger forest blocks and hence metapopulations of certain species that require these corridors to maintain viable populations (corridor species). A separate study is assessing the feasibility of REDD funding as a way of providing incentives to conserve these forests and this will also assess whether a premium price could be obtained because of the biodiversity value of these forests.

2.0. Introduction

The UNDP/GEF project for the *Conservation of Biodiversity in the Albertine Rift Forests of Uganda* was established to conserve the biodiversity of the forests in the Murchison-Semliki landscape of the Albertine Rift in western Uganda. Managed by the World Wide Fund for Nature (WWF) it had a component to measure the biodiversity of the Central Forest Reserves and the remaining forest on private land in this landscape. This component of the project was sub-contracted to the Wildlife Conservation Society (WCS) because of our extensive experience with biodiversity surveys in Uganda. Due to limited funding available the project has focused in 2010 on the Bugoma Forest Reserve and the central forest reserves and private forests to the south of Bugoma and to the south west towards Itwara Forest Reserve (figure 1).

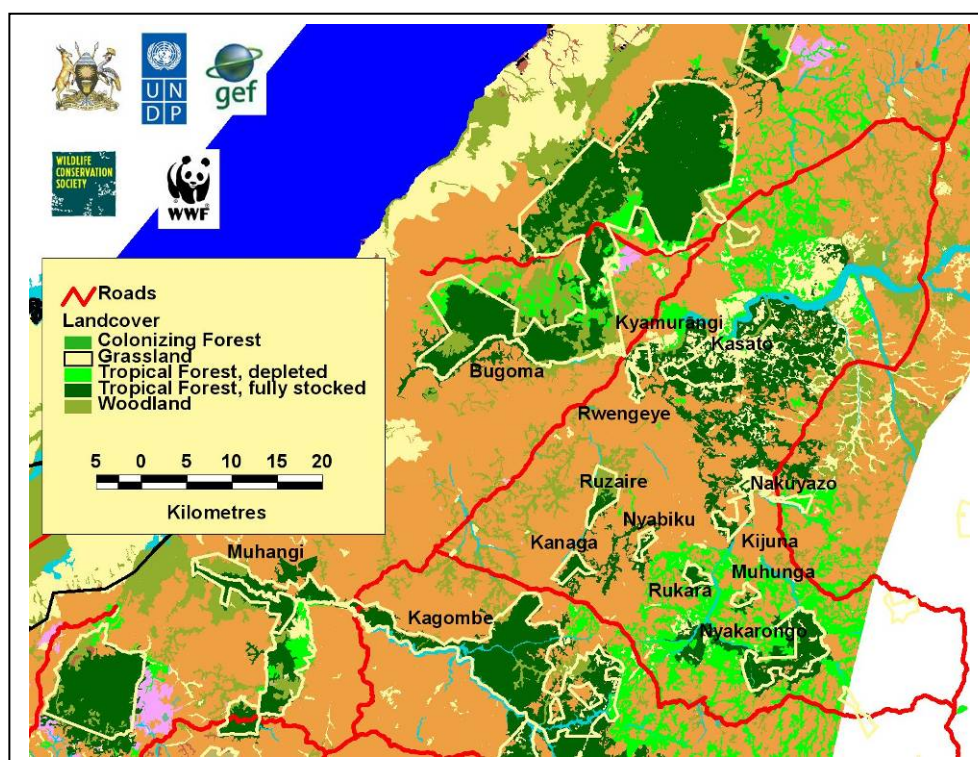


Figure 1. Location of the Central Forest Reserves (white outline - named) and private forests surveyed.

Prior surveys have been made of some of these forests in the past. In 1999 WCS and Jane Goodall Institute (JGI) surveyed Bugoma Forest Reserve and Kagombe Forest Reserve as part of a wider survey of large mammals, particularly chimpanzees in Uganda (Plumptre *et al.*, 1999). Surveys of trees and shrubs, small mammals, birds, butterflies and hawk and silk moths were made of Bugoma Forest Reserve (Davenport, Howard and Matthews, 1996) and Kagombe Forest Reserve (Howard and Davenport, 1996) as part of the Uganda Forest Department's surveys of biodiversity across its forest estate (Howard, Davenport and Kigenyi, 1997). These surveys ranked Bugoma 12th and Kagombe 31st in terms of overall biodiversity importance out of the 65 forests surveyed in the country (Uganda Forest Department, 2002). However none of the other 13 central forest reserves (CFRs) in this landscape (figure 1) or the connecting private forests have been surveyed for their biodiversity.

As part of the planning process for the conservation of the Murchison-Semliki landscape, WCS made an analysis of critical corridors in the landscape that if conserved would ensure connectivity between the forest reserves for certain landscape species (Nangendo, Plumptre

and Akwetaireho, 2010). The surveys outside the CFRs reported here focused on the corridor areas identified in this analysis (figure 2). Landscape species used to assess corridor requirements for the forest corridors included chimpanzees (*Pan troglodytes*), Golden cats (*Profelis aureus*), large and small forest raptors, and under storey birds that are known to move between forests (such as Pittas). These species and species groups were thought to represent the requirements of other similar species (eg. Golden cats would represent other medium sized carnivores such as jackals).

Although biodiversity has been partially surveyed in this landscape it was clear that a better understanding of then biodiversity distribution in the forests of the Murchison-Semliki landscape was needed. WWF therefore subcontracted WCS to make these surveys in the forests shown in figure 1.

The biodiversity surveys aimed to meet the following objectives:

1. To compare the biodiversity richness of the corridor forests and small CFRs with the main block of Bugoma.
2. To assess whether key landscape species are using the forest corridors at present.
3. To assess the distribution and relative abundance of threatened species in this landscape.
4. To assess trends in abundance of species whose populations were surveyed in 1999.
5. To assess the availability of carbon in the landscape from plot measurements of trees.

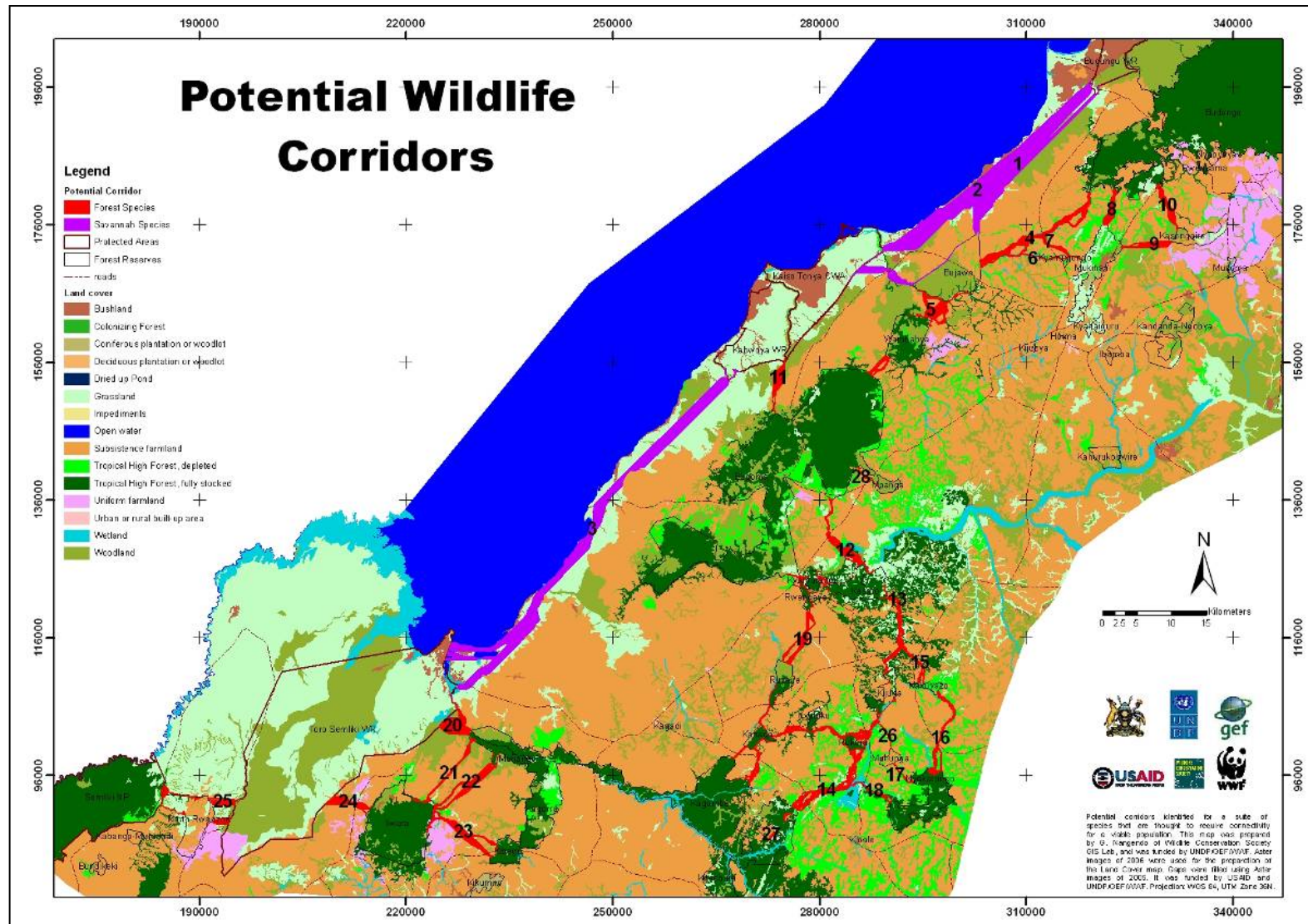


Figure 2. Critical corridors for maintaining connectivity for landscape species in the Murchison-Semliki landscape.

3.0 Survey Methods

The methods used to measure the biodiversity of these forests focused on three main taxa: large and medium sized mammals, birds, and trees and shrubs as surrogates of total biodiversity. Howard, Davenport and Kigenyi (1997) showed that there was a reasonable correlation between species richness in the five taxa they selected between sites and estimated that birds alone were a good indicator of most other biodiversity in Uganda's forests (Howard *et al.*, 2000).

In the small CFR's sampling points were selected using a stratified systematic design using the software DISTANCE 6.2 (Thomas *et al.*, 2009). Regularly spaced points at a distance of about 1 km were randomly allocated to each of four habitat types derived from the landcover map that had been compiled by WCS (figure 1). These four habitat types included: mature tropical high forest, degraded tropical high forest, woodland and grassland. A spacing of 1 km was selected as desirable because it seemed to be a good trade off between number of points to survey and distance required to travel between points. DISTANCE generated the GPS positions of the points selected and these were copied to an excel spreadsheet and then entered into GPS units so that field teams could locate the points easily. Each point was given a separate number to allow for tracking of the point data when collected and these were mapped (figure 3).

In Bugoma and Kagombe CFR 3 km line transects were established from a similar design in DISTANCE. In this case coverage probability maps were calculated using transects with different lengths and orientation to determine the best orientation. North-south proved to be the best solution and 36 transects were established in Bugoma Forest and 7 in Kagombe (figure 3).

3.1. Large and medium sized mammals

Reconnaissance walks (Recces) were the primary method used to survey between the points in the small CFRs and private forests in the forest corridors. A team of two Ugandan Field Assistants moved between points, generally in as straight a direction as possible but moving around obstacles such as dense vegetation on the way. As such these are not strict transects and suffer from some bias but it has been found for Uganda's forests that there is a good correlation between reconnaissance encounter rates of chimpanzee nests and densities of chimpanzees (Plumptre and Cox, 2005) and the method allow much longer distances to be covered under the same survey. Recces were used to identify locations where specific species were observed as well as the calculation of encounter rates per km walked. Recces were made between June and November 2010.

Transects established in Budongo and Kagombe were visited several times over a 2-3 month period between August and October 2010 ensuring that each transect was visited every 15 days or less. This has been found to be the shortest time for a chimpanzee nest to decay to a point that it would not be counted. Occasionally a transect might not be visited within this period but the time did not extend beyond 20 days and it is thought that this will not have had much impact on the final result.

All sightings of large mammals were recorded on both recces and transects. In addition the dung of elephants, bushpigs and buffalo were recorded and nests of chimpanzees. On transects perpendicular distances from the centre of the transect were measured to all observations to allow densities to be computed if sample sizes were large enough. All signs of human impact were also noted on both recces and transects. GPS locations were taken using GARMIN 60Csx units for all observations made. The marked nest count method was used to analyse densities of chimpanzees (Plumptre and Reynolds, 1994; 1996).

Biodiversity surveys of Bugoma and other small CFRs and private forests.

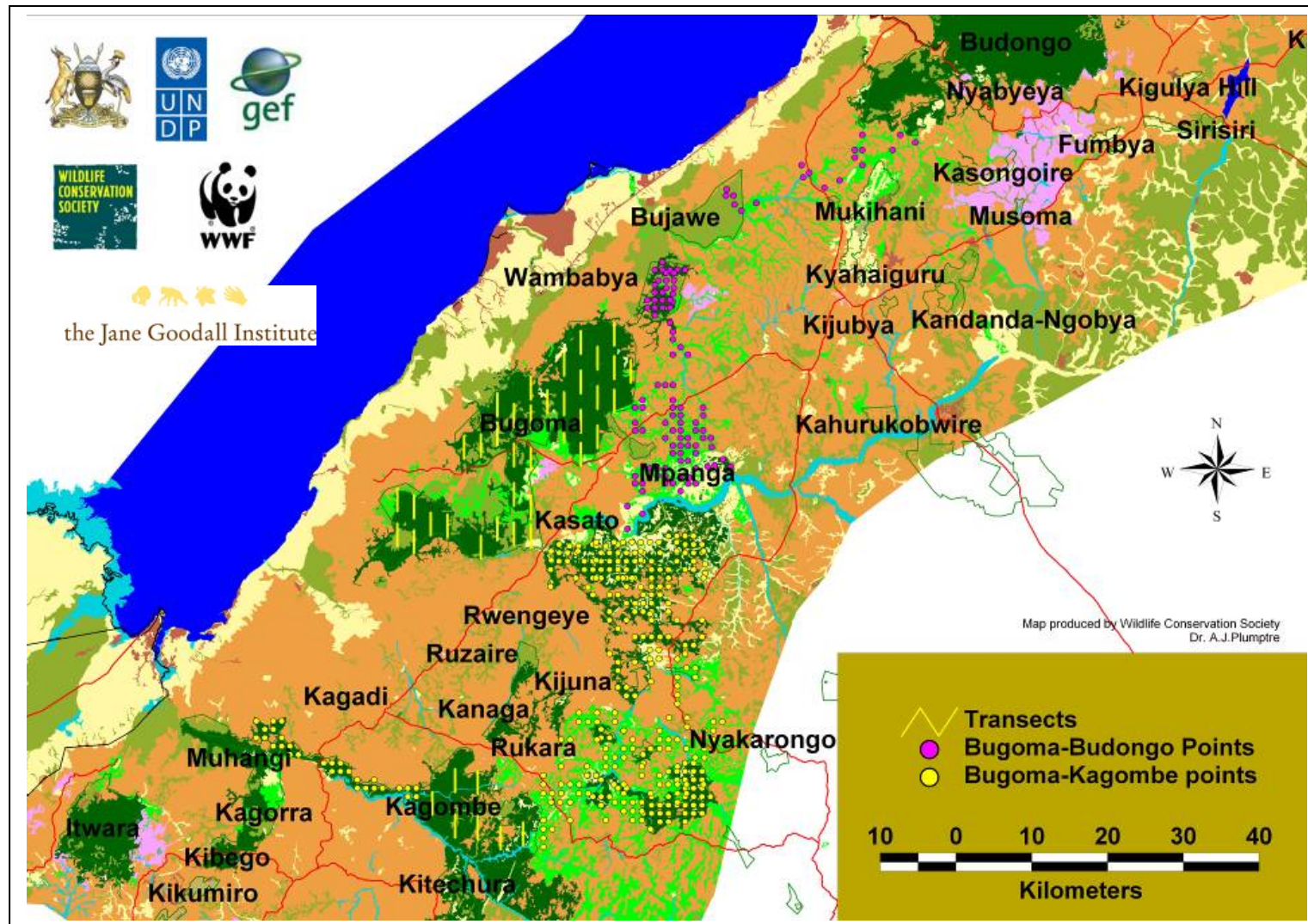


Figure 3. Locations of survey points (yellow circles) surveyed in the small CFRs and private forests together with transects (yellow lines). Pink points are sites that are currently being surveyed with funding from JGI and CSWCT.

Camera traps (Camtracker and Recon units) were also placed in the corridor forests (small CFRs and private forests) to identify other medium-sized mammals might be using these forests which wouldn't be observed on recce walks. Camera traps were left for 1-2 months at each site surveyed because the capture rates were very low. No film was completely used in the traps that used film.

Finally people living in households next to the forests were asked about the species they have observed in the forests and lists were made for each village of these species. A mammal guide (Kingdon, 1997) was used to make sure people's identifications were correct.

3.2. Birds

Point counts of all bird species were made at each sampling point in the small CFRs and private forests and every 250 metres along the line transects in Bugoma and Kagombe. Two experienced ornithologists who know forest bird calls would visit each point, wait 2 minutes for the birds to settle down and then count all birds seen or heard at the point estimating the distance from the point centre to the bird in distance categories (0-10m, 10-20m, 20-50m; 50-100m; 100-200m, 200-500m).

Additionally all sightings of "corridor birds" (table 1), species for which corridors may be important for populations, were recorded if observed or heard when moving along the recce lines between points.

Bird richness data were analysed using Biodiversity Professional, software developed by the London Museum of Natural History using rarefaction calculations, calculation of Shannon Wiener and Log-Alpha diversity indices and clustering bird communities in different forests or forest types.

Table 1. List of bird species that may need ecological corridors in the Northern Albertine Rifts to maintain viable populations

No.	Species name		Conservation status	Comments/Remarks
	Common name	Scientific name		
Large birds of prey (osprey, vultures, hawks, eagles etc)				
1.	African Crowned Eagle	<i>Stephanoaetus coronatus</i>	R-VU	Predominantly a resident of thick forest or large forest patches. Confined to the forested regions of S and SW where is sometimes common up to 4,000m
2.	Ayres’s Hawk-Eagle	<i>Hieraaetus ayresii</i>	R-VU	Habitat: resident of woodland and forest, found mainly below 1,500m but occasionally up to 2,300m, considered to be very scarce in the W Uganda forests. Little-known, and probably genuinely scarce
3.	Cassin’s Hawk Eagle	<i>Spizaetus africanus</i>	Reported as being uncommon and there are few recent records	Resident of dense forest, mainly below 1,500m
Large Frugivores				
4.	Black and White Casqued Hornbill	<i>Ceratogymna subcylindricus</i>	Relatively common	Needs mature trees to nest in
5.	White-Thighed Hornbill	<i>Ceratogymnas cylindricus</i>	G-LR/nt	The race <i>albotibialis</i> of equatorial forests to the W of Uganda, and reaches 1,150 m in the medium-altitude W Uganda forests. There

				several recent records from Budongo forest.
6.	All tauraco species			
7.	African Grey Parrot	<i>Psittacus erithacus</i>	Collected for pet trade	Need forest but fly out to sites around
Falcons and smaller birds of prey				
8.	Greater Sparrowhawk	<i>Accipiter melanoleucas</i>		Found in forest
9.	Lesser Sparrowhawk	<i>Accipiter minullus</i>		Found in forest
10.	African Goshawk	<i>Accipiter tachiro</i>		The race <i>sparsimfaciatus</i> is a resident of wooded areas and forest edge. It generally occurs in moister areas up to 2,000m, notably in the S and SW, from the forests of W Uganda to Kampala gardens with large trees but usually avoids drier, more open places
Understorey/Riparian species				
11.	Pel's fishing-Owl	<i>Scotopelia peli</i>	R-VU uncommon/rare owl	Found near rivers up to 1,700 m, especially in clumps of large riparian trees with branches overhanging the water, which provide dense shed and riverine forest.
12.	Rufous-sided Broad Bill	<i>Smithornis rufolateris</i>	Is less wide spread than the African Broad bill with which it forms a super species	The race <i>budongoensis</i> occurs only in primary forests clustered around L Albert-Bugoma, Budongo and Bwamba where it inhabits dense undergrowth
13.	Common Pitta	<i>Pitta angolensis</i>	Noted infrequently	It occurs in dense understorey vegetation and thick tangles of climbers in medium-altitude forest up to 1,400m.
14.	Green-Breasted Pitta	<i>Pitta reichenowi</i>	Noted infrequently	It occurs in dense understorey vegetation and thick tangles of climbers in medium-altitude forest up to 1,400m. There have been only 4 records since the 1960's, all from the forests of the west.
15.	Green-Tailed Bristle Bill	<i>Bleda eximia</i>	Common in Bwamba Forest but, elsewhere it is local and uncommon	It inhabits the understorey, often near ant trails; the race <i>ugandae</i> is confined to the medium altitude forests of Bwamba, Bugoma and Budongo.
16.	Nahan's Francolin	<i>Francolinus nahani</i>	G-EN, RG-VU.	Habitat: Confined to dense, mature, moist, sometimes swampy medium-altitude forest below 1,500m, Quite common in Budongo and Mabira forests.

Key: G-EN - globally endangered; G-VU - globally vulnerable; G-LR/nt - globally lower-risk, near threatened; R-EN - regionally endangered; R-VU - regionally vulnerable; R-NT - regionally near-threatened;

3.3 Trees and shrubs

At each sampling point in the CFRs and private forests a 20 metre radius circular plot was established with nested circular plots centered on the centre of the main plot. Similarly plots were established at the ends of the transects in Bugoma Forest. The following measurements were taken:

0-2m radius: Trees/shrubs >1 m tall and less than 4.9cm DBH

0-5m radius: Trees/shrubs 5-9.9cm DBH

0-10m radius: Trees of 10-29.9cm DBH

0-20 m radius: Trees 30cm+ DBH

The name of the tree, the DBH, the height to the first branch and the height to the top of the canopy in meters were measured and recorded.

Tree and shrub richness data were analysed using Biodiversity Professional, software developed by the London Museum of Natural History using rarefaction calculations, calculation of Shannon Wiener and Log-Alpha diversity indices and clustering tree and shrub communities in different forests or forest types.

4.0 Results

4.1. Large and medium-sized mammals

4.1.1. Recce walks and transects- mammal locations

A total of 156.17 kilometres of recces were walked in the small CFRs and private forests (figure 4). A total of 386.9 km of transect was also walked in Bugoma and Kagombe CFRs with support from the Jane Goodall Institute for the surveys in Bugoma.

Figure 5 gives the locations of primates observed on the recce and transect walks. This shows that in the area surveyed the Uganda mangabey (*Lophocebus ugandae*) an endemic species to Uganda was only observed in Bugoma CFR. Black and white colobus (*Colobus guereza*) were observed throughout the corridor forests as well as in the main blocks of Bugoma and Kagombe. Redtail monkeys (*Cercopithecus ascanius*) and nests of chimpanzees (*Pan troglodytes*) were observed in the larger blocks of forest in the corridors, mostly in small CFRs, but were more common in the main forest block of Bugoma. Blue monkeys (*Cercopithecus mitis*) were very rarely observed as was the case in 1999. Why they occur at very low density in this region is unclear and after 11 years it is unlikely to be attributable to disease. Interestingly this species also occurs at very low density in Kibale National park in Uganda where the Uganda Mangabey also occurs. Elsewhere it is relatively abundant where it occurs in Uganda's forests.

Figure 6 shows the locations of elephant dung observed on the recces and transects and village reports of elephant and hippo sightings. Figure 7 gives the locations of village reports of golden cats and jackals. Villages around the main block of Bugoma and Kagombe were not sampled but it people reported that medium-sized carnivores such as golden cat and jackals use the forest corridors at present. Elephants were confined to Bugoma and Kagombe CFRs and hippopotamuses still occur in the wetland of Kagombe CFR. These two large herbivores were noted in the WCS/JGI surveys in 1999 and it was surprising to still find them in Kagombe CFR despite the intense human pressures on this forest reserve.

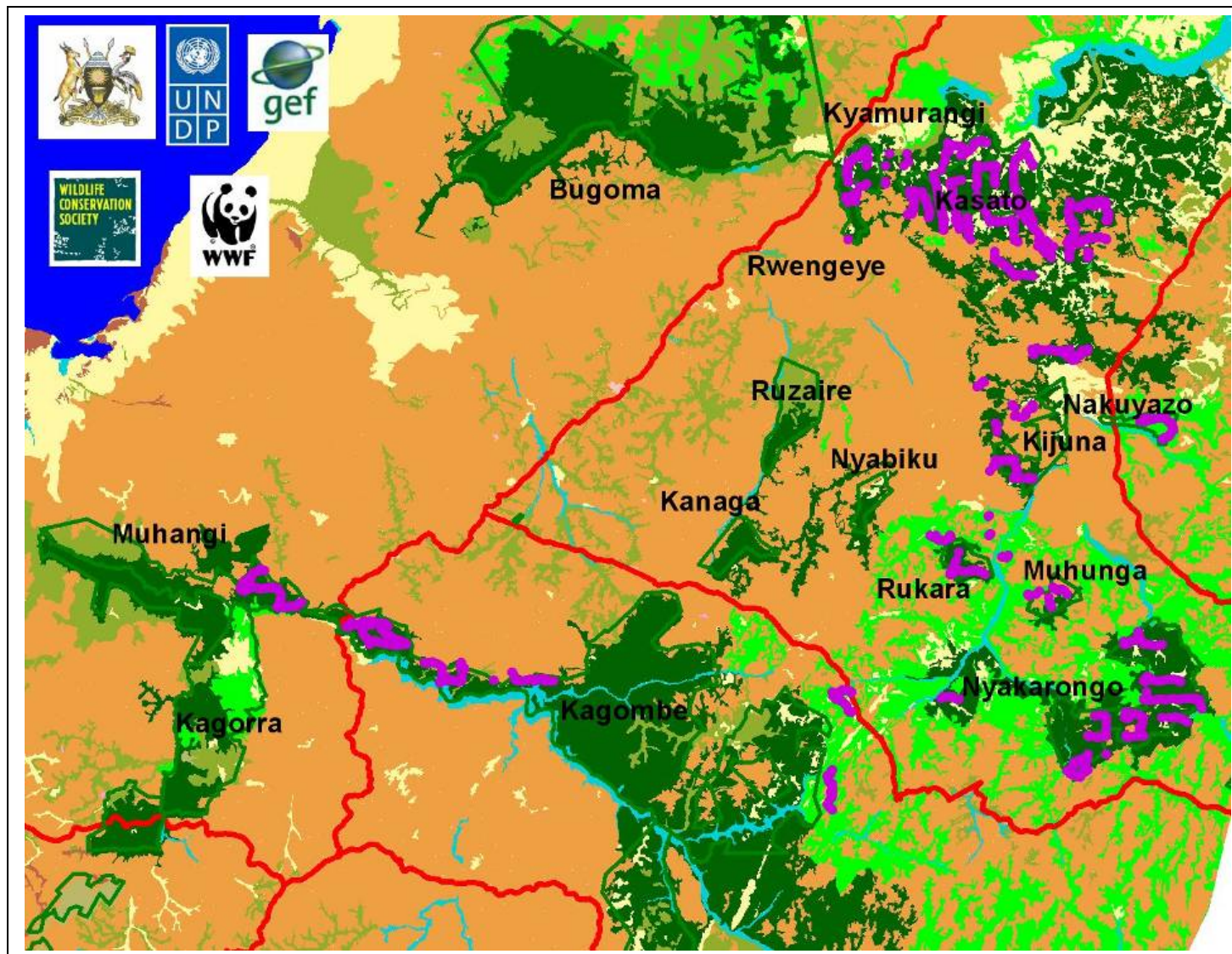


Figure 4. Areas surveyed (purple lines) on recce walks in the small CFRs and private forests.

Biodiversity surveys of Bugoma and other small CFRs and private forests.

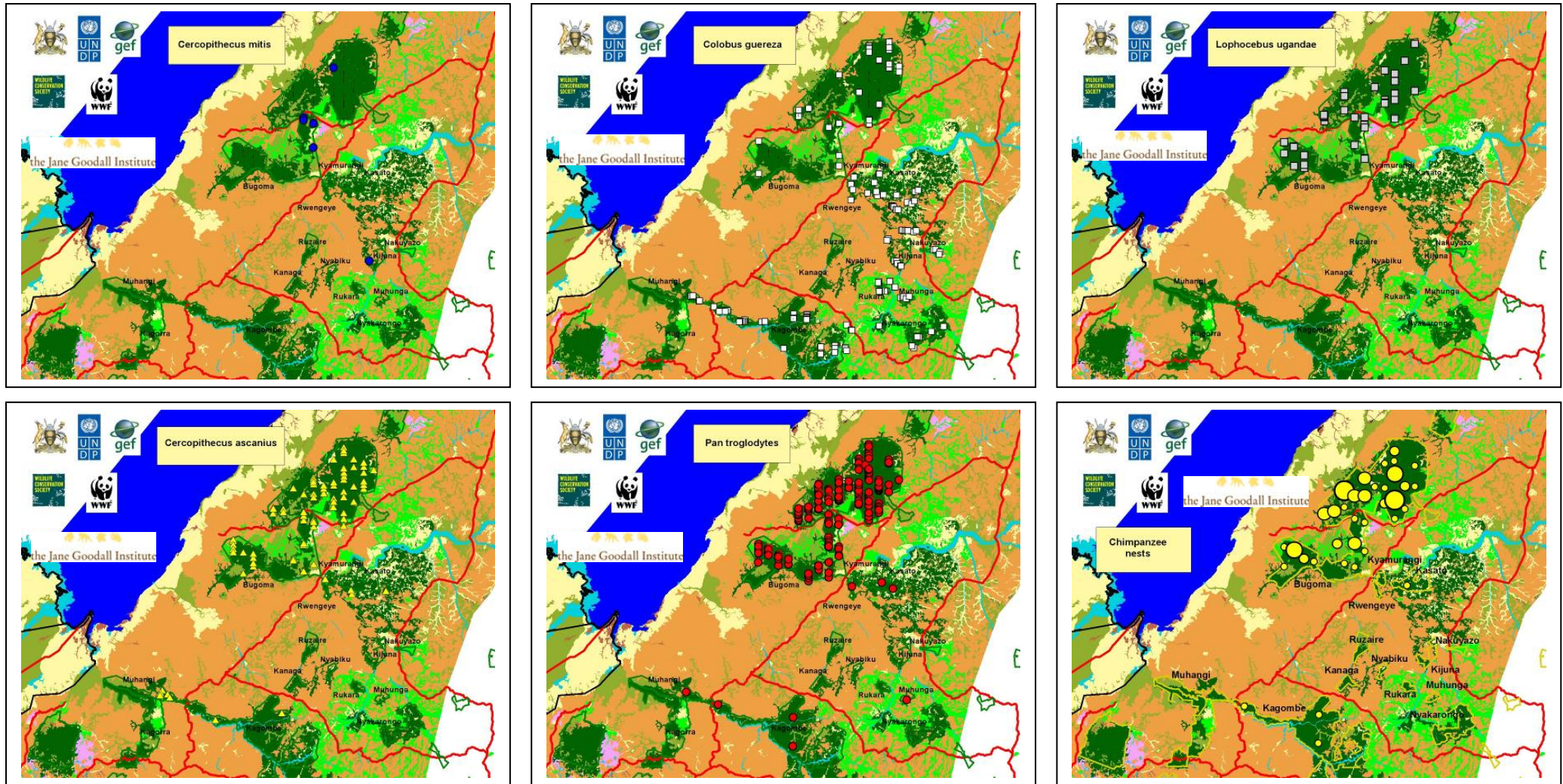


Figure 5. The locations of sightings of blue monkeys (top left), guereza colobus (top centre), Uganda mangabey (top right), redbtail monkey (bottom left) and chimpanzee nests (bottom centre). The encounter rate of chimp nests per km walked is also given (bottom right).

Two maps of human impacts on the forests were made using the sightings data. One of logging sign (pitsaw sites, felled trees and planks of timber) and the other of poaching sign (snares and pitfall traps) which show that while signs of poaching are sparse, felling of trees for timber is rampant throughout the region (figure 8).

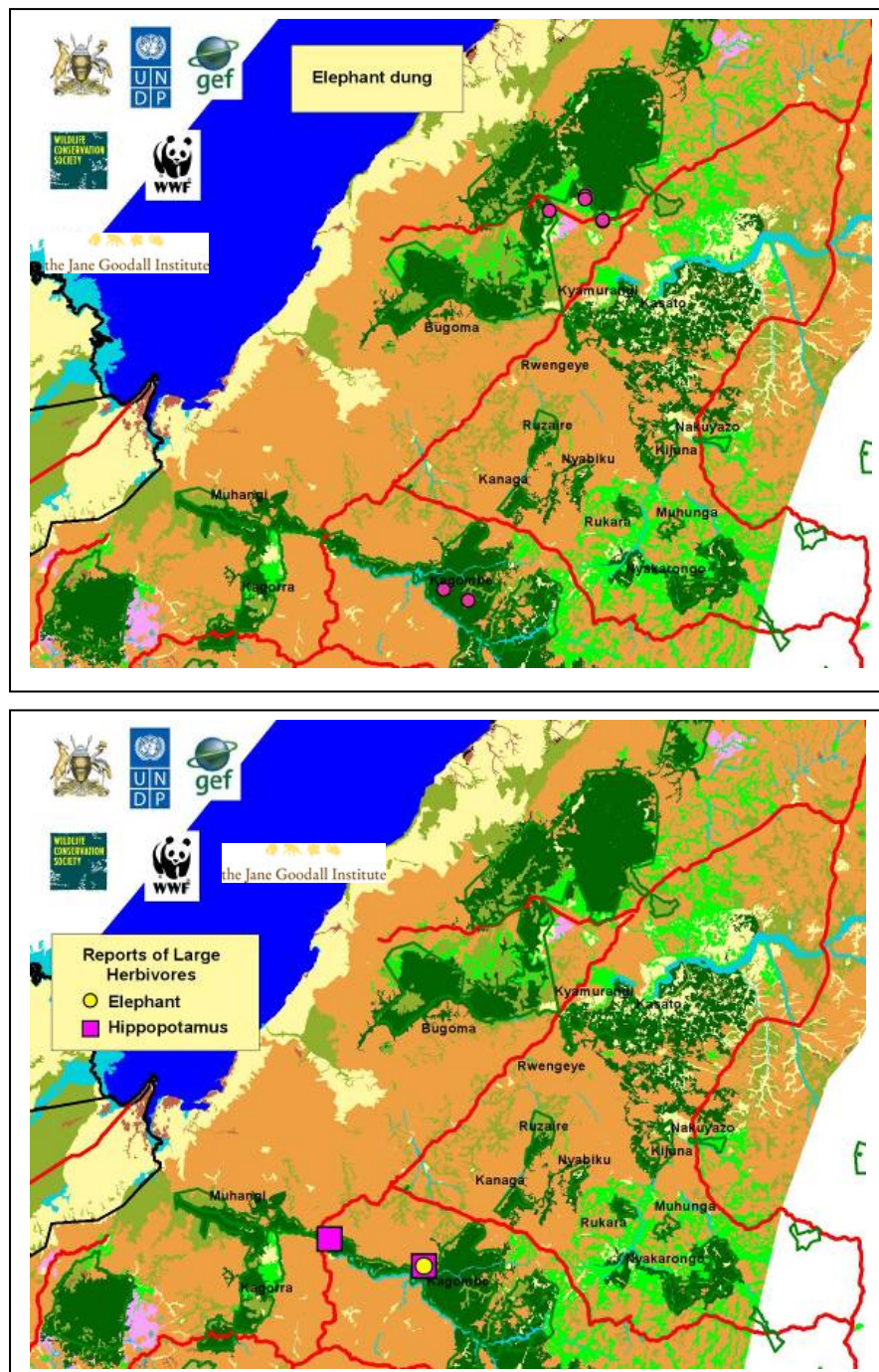


Figure 6. Locations of sightings of elephant dung (top) and reports of elephants and hippopotamuses (bottom) by villages adjacent to the forest.

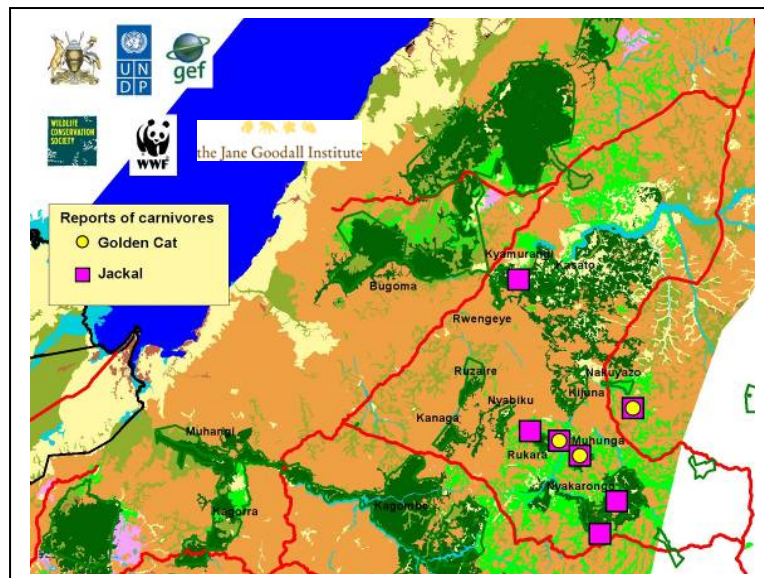


Figure 7. Locations of households in villages that reported sighting golden cats and jackals in the forest.

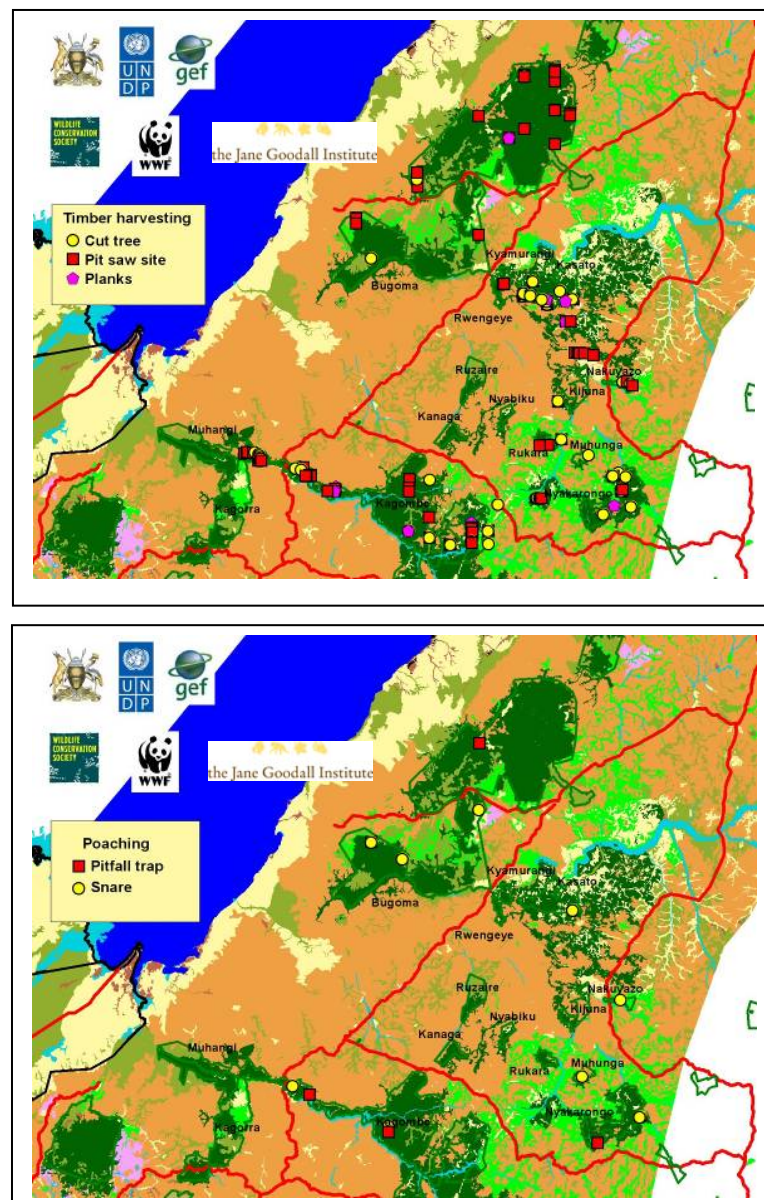


Figure 8. Signs of human impact: timber harvesting sign (top) and poaching sign (bottom).

4.1.2. Camera trap analysis

A total of 2,149 camera trap days were used to compile photographs of medium sized mammals in the corridor forests (small CFRs and private forests). Most locations were within forest reserves because of the risk of having cameras stolen (figure 9).

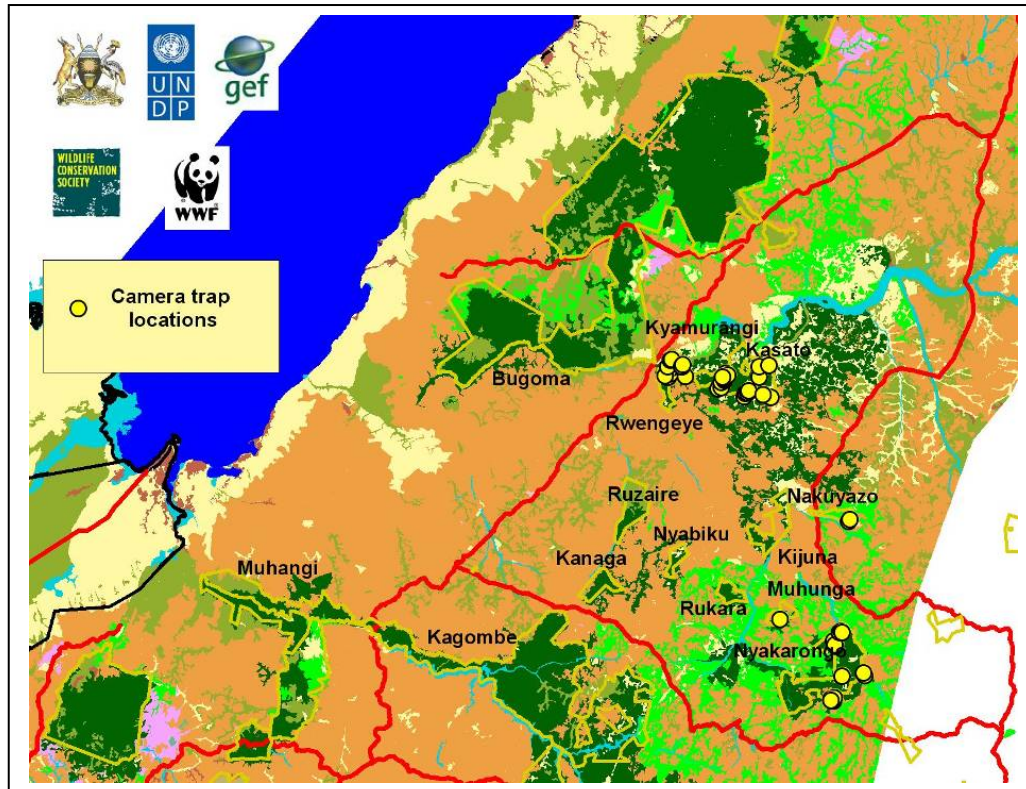


Figure 9. Location of camera traps in small CFRs and a few sites in private forest.

Table 2. Encounter rates (number of photographs per 100 trap nights) of species caught on camera traps.

Species	Kasato Reserve	Kyamurangi Reserve	Nakuyazo	Nyakarongo	Muhunga	Trap rate all forests
Trap days	918	43	165	1,023	30	2,149
African Civet	0.11	0.00	0.00	0.00	0.00	0.05
Baboons	7.19	0.00	0.00	0.00	0.00	3.07
Blue Duiker	0.22	0.00	0.00	0.00	0.00	0.09
Bush Duiker	0.00	0.00	0.00	0.10	0.00	0.05
Bush Pig	0.22	0.00	0.00	0.00	0.00	0.09
Bushbuck	0.22	25.58	0.61	5.67	0.00	3.35
Guinea fowl	3.05	13.95	0.00	0.88	0.00	2.00
Servaline Genet	0.44	0.00	0.00	0.00	0.00	0.19
Side-striped Jackal	0.33	0.00	0.00	0.00	0.00	0.14
Weyn's Duiker	0.11	0.00	0.00	0.00	0.00	0.05
No. species	9	2	1	3	0	10

The encounter rates (number of animals photographed per 100 trap days) show that Kasato CFR tended to have more species (9) photographed compared with the other sites (table 2). Although a trap was placed at Muhunga CFR nothing was photographed and it has been left off the table. At Kyamurangi CFR there was a relatively high capture rate for bushbuck and guineafowls but this may be partially due to the low number of traps placed here leading to only 43 trap days. It might be that with more trap days the encounter rate would drop. Of the corridor species no chimpanzees or golden cats were photographed but another medium sized carnivore, the side-striped jackal (*Canis adustus*), was captured in Kasato CFR on two separate occasions. This species has also been recorded from other forests in Uganda (Treves *et al.*, 2010) where WCS has been camera trapping.

4.1.3. Trends in mammal numbers

Densities of primates were calculated for Bugoma and Kagombe CFRs from the transect walks (table 3). Comparisons with the census of the same species in these forests in 1999 show that most species have not changed significantly in Bugoma with an increase in the black and white colobus (*C. guereza*) observed. The same species has also increased markedly in Kagombe CFR. In Kagombe it was not possible to calculate a density of chimpanzees (*P. troglodytes*) from marked nest counts because of time and financing constraints. An estimate using nest decay rates from Budongo Forest (Plumptre and Reynolds, 1994; 1996) would give a density estimate of chimpanzees in Kagombe of 0.21 km⁻² (se: 0.12) which would be a significant decline ($P < 0.05$).

Table 3. Densities (no km⁻²) of primate groups and of individual animals in Bugoma and Kagombe CFRs in 1999 and 2010.

Species	1999		2010		
Bugoma	Group density (se)	Individual density (se)	Group density (se)	Individual density (se)	Z-test Ind density
<i>Colobus guereza</i>	0.49 (0.15)	2.59 (0.54)	2.21 (0.57)	8.55 (2.36)	P<0.01
<i>Lophocebus ugandae</i>	1.69 (0.42)	8.23 (2.04)	1.25 (0.35)	6.33 (2.06)	Ns
<i>C. ascanius</i>	5.93 (0.73)	20.21 (3.03)	5.23 (0.94)	25.74 (5.25)	Ns
<i>Pan troglodytes</i>	1.87 (0.27)	1.90 (0.28)	1.24 (0.30)	1.24 (0.30)	Ns
Kagombe					
<i>Colobus guereza</i>	1.30 (0.36)	4.75 (1.32)	8.96 (4.21)	34.65 (16.67)	P<0.05
<i>Pan troglodytes</i>	0.63 (0.26)	0.71 (0.27)			

4.1.4 Trends in human impacts

We can also compare the encounter rates of human impacts; particularly logging signs, poaching signs and total human signs encountered per km of recce or transect walked (figure 10). In 1999 only Bugoma, Kasato and Kagombe were surveyed and it is the relative impacts that need to be considered when comparing these figures (Table 4). The results show that relatively the encounter rates of illegal activities appear to have declined in Bugoma but increased for logging and total human sign in Kagombe. In Kasato CFR logging and human sign have increased dramatically with a lot of harvesting of poles for building and sticks for bean stakes contributing to most of the total human sign.

Table 4. Encounter rates (no km-2) for three different categories of human impact: hunting signs (snares, pitfall traps, carcasses of animals etc); logging (pitsaw sites, planks, cut trees etc) and total human sign (includes logging and hunting as well as collection of NTFP, footpaths, fireplaces etc)

Forest	Hunting sign		Logging Sign		Total Human sign	
	1999	2010	1999	2010	1999	2010
Bugoma	0.120	0.040	0.259	0.081	0.503	0.214
Kagombe	0.211	0.099	0.326	9.456	0.567	10.565
Kasato	0.358	0.027	0.179	3.429	0.597	29.732

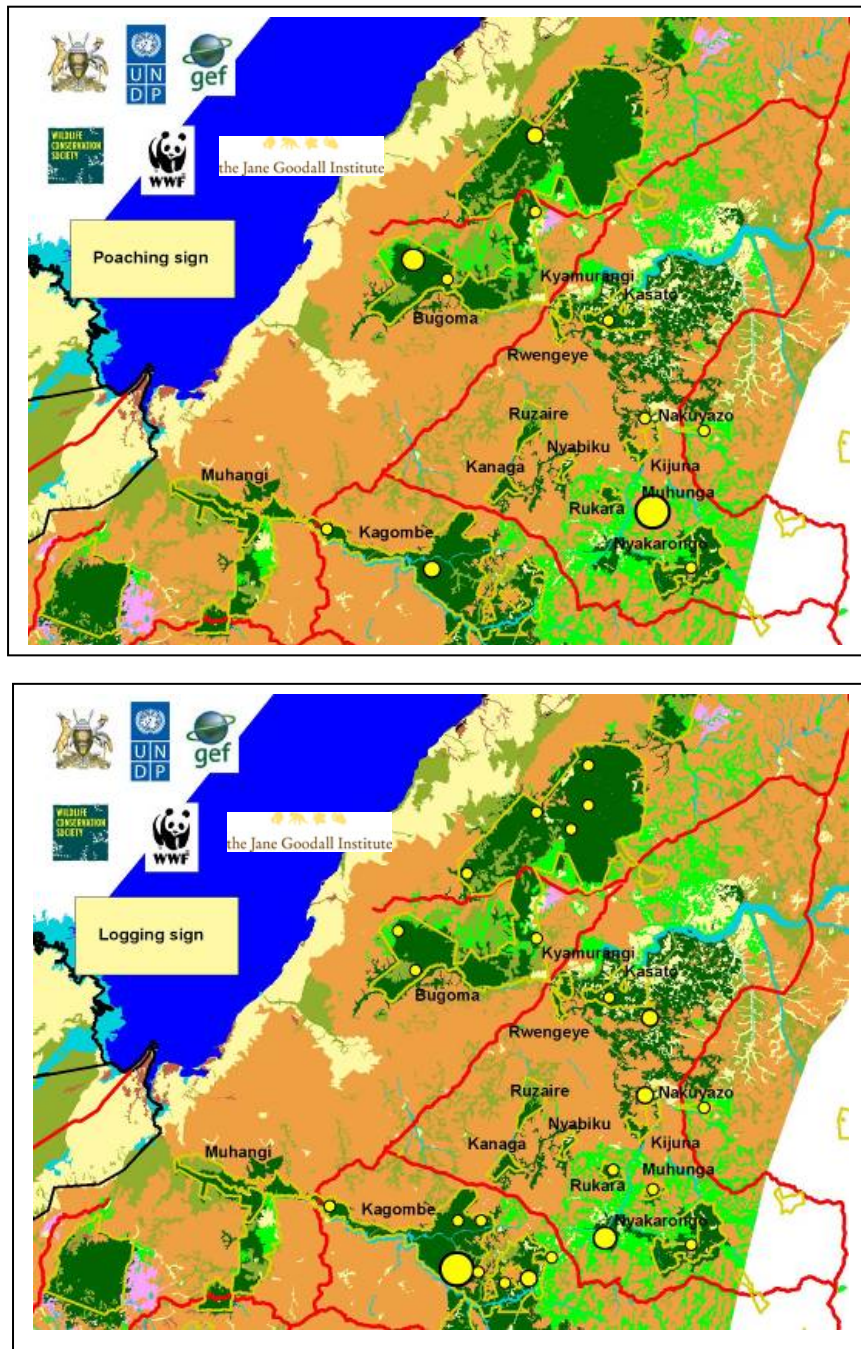


Figure 10. See legend on next page

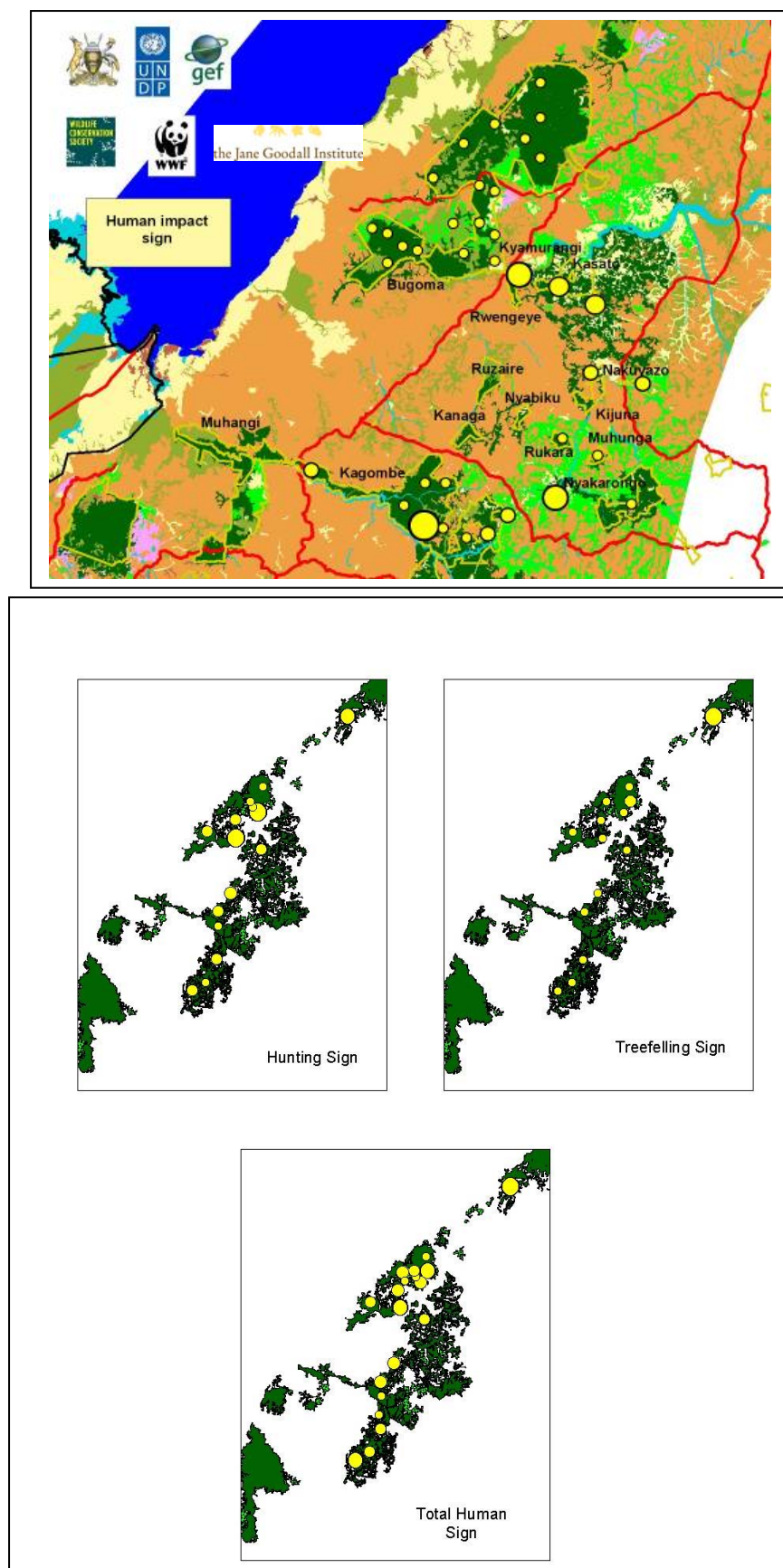


Figure 10. Comparison of human threat encounter rates per km walked in 2010 (top three) and 1999 (bottom three) for poaching/hunting sign; logging/treefelling sign and total human sign/

4.2. Birds

4.2.1. Species richness

A total of 194 bird species were recorded in these surveys. This compares favourably with the 221 species that have been recorded for Bugoma CFR (Plumptre *et al.*, 2007) and 121 for Kagombe CFR (Howard and Davenport, 1996). Species richness was higher in the smaller corridor forests (figure 11) than in Bugoma CFR which initially was surprising.

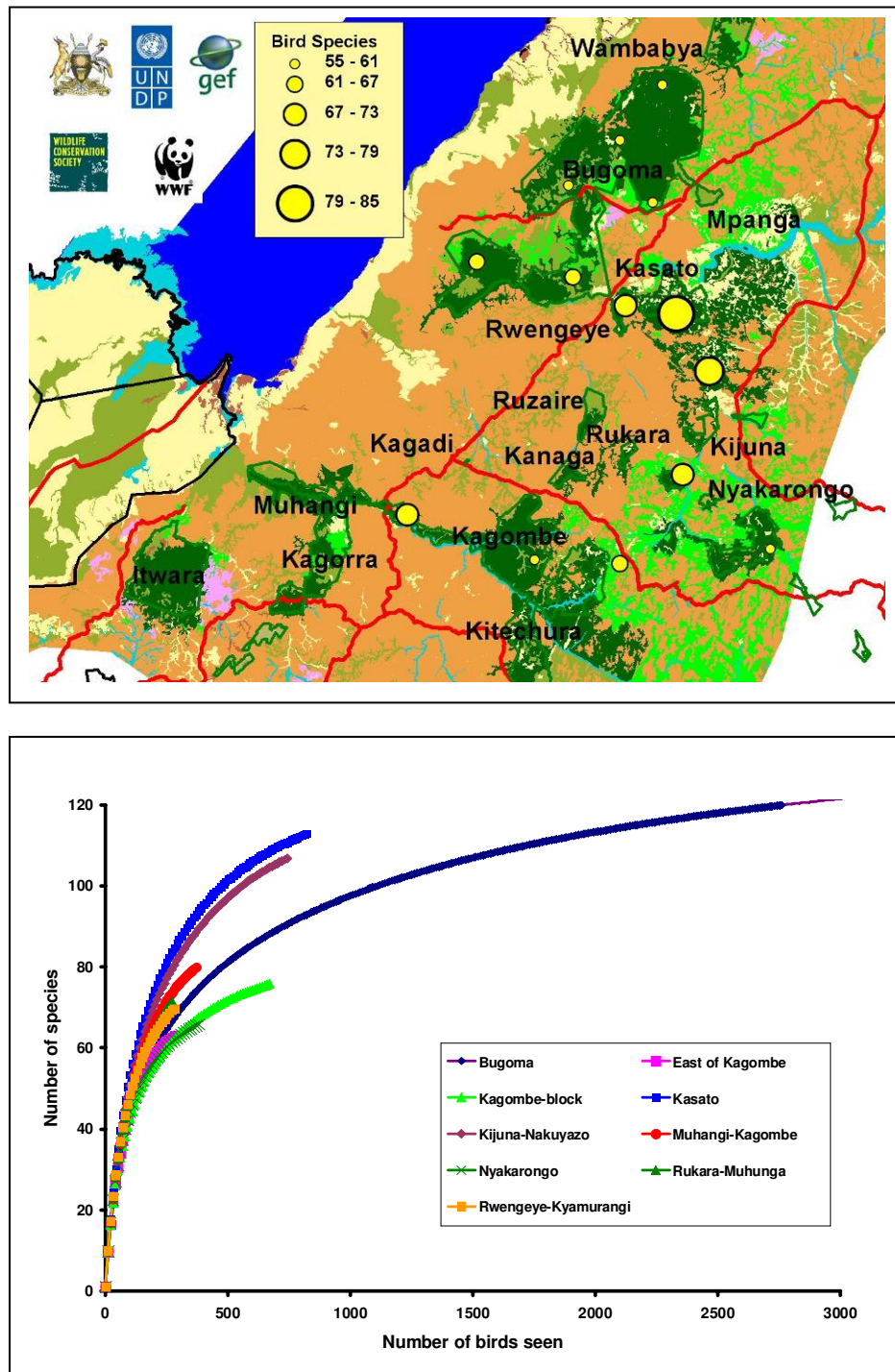


Figure 11. Relative species richness by site (top) and rarefaction curves of these same sites (bottom).

However, if bird species richness is analysed by habitat type at each point count it can be seen that cultivated land adjacent to forest and degraded forest also have more species of birds than tropical high forest that is relatively undisturbed. This is because there are more species that are non-forest or forest edge species (figure 12).

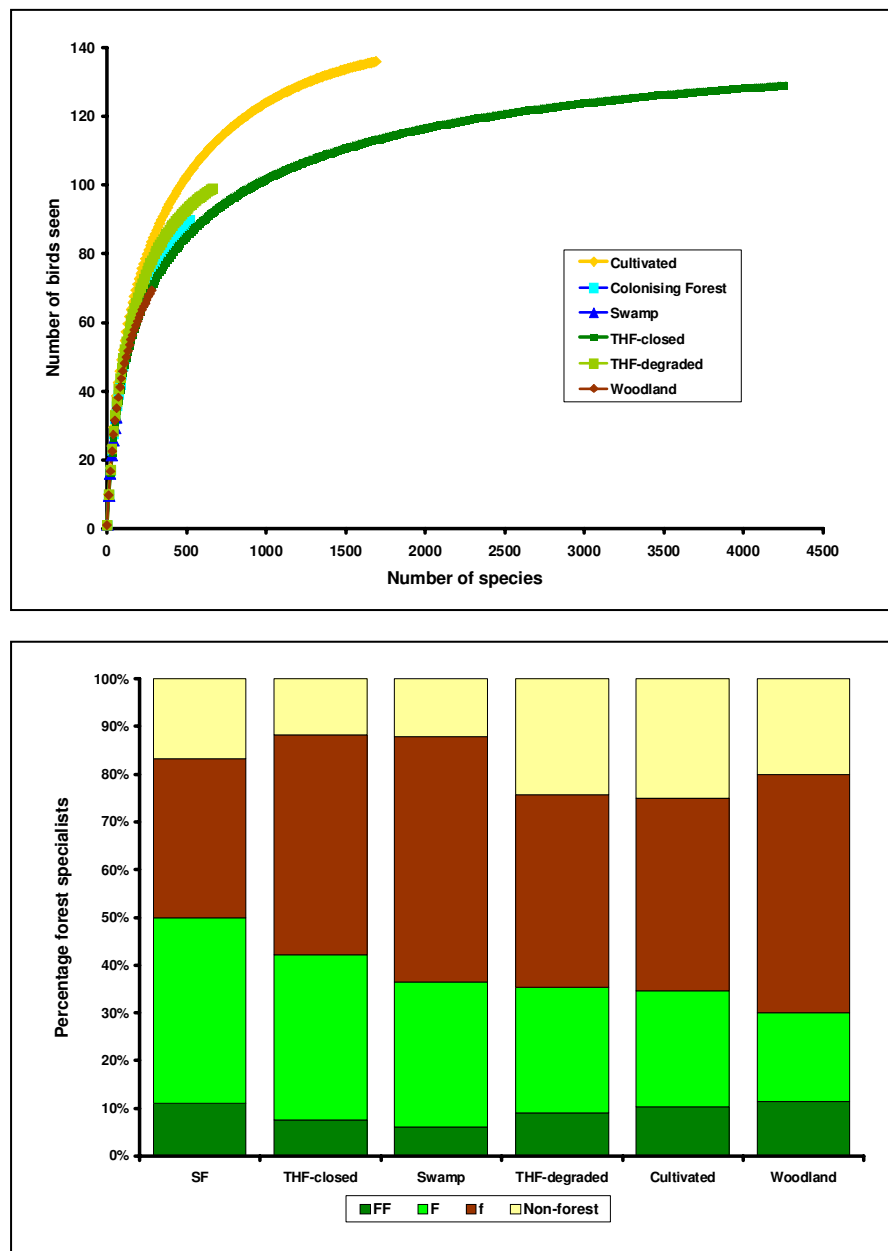


Figure 12. Rarefaction curves for bird species in different habitat types (top) and percentage of forest specialist species (FF), forest dependent (F), Forest edge (f) and non forest species for each habitat (bottom). SF=short stature forest or colonizing forest; THF – tropical high forest.

Assessment of the number of forest specialist (FF), forest dependent (F), forest edge(f) and non-forest birds (produced by Makerere University Biodiversity Databank, Kampala for East African Birds) by sites showed that Nyakarongo and Kasato CFRs had higher percentage numbers of FF and F species than Bugoma CFR (figure 13). This may be because there are parts of Bugoma that are grassland or woodland.

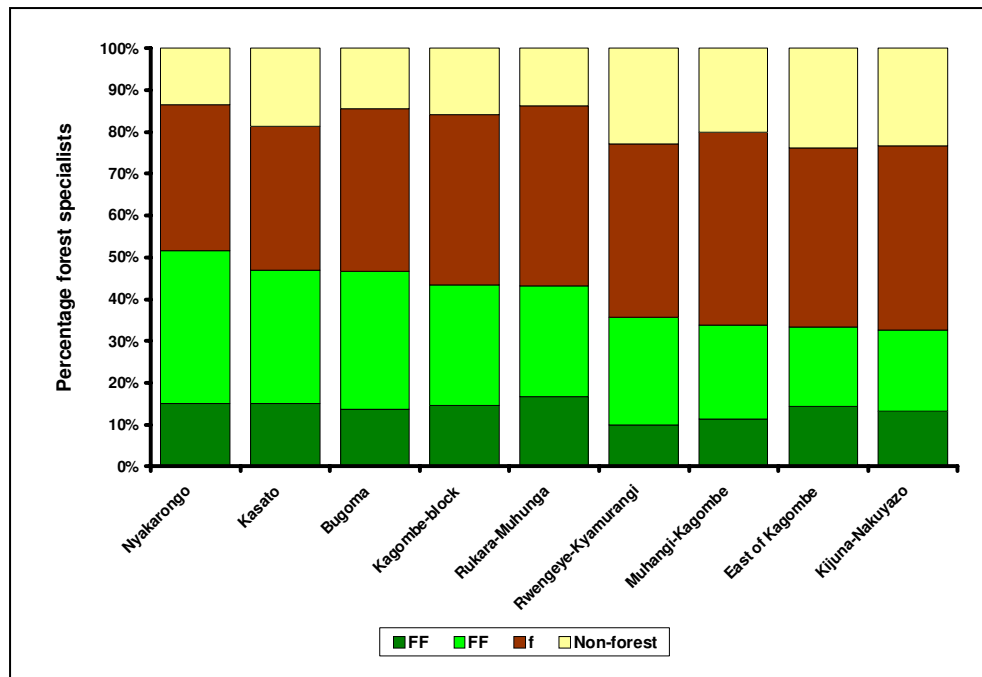


Figure 13. The percentage of forest specialist species (FF), forest dependent (F), Forest edge (f) and non forest species for each habitat (bottom).

Comparison of the bird community by site using a Jaccard cluster analysis showed that the bird community in Bugoma and Kagombe were similar in species composition, those in the smaller forests south of Bugoma were similar and then Nyakarongo, east of Kagombe and Rwengeye-Kyamurangi tended to differ from the other sites (figure 14).

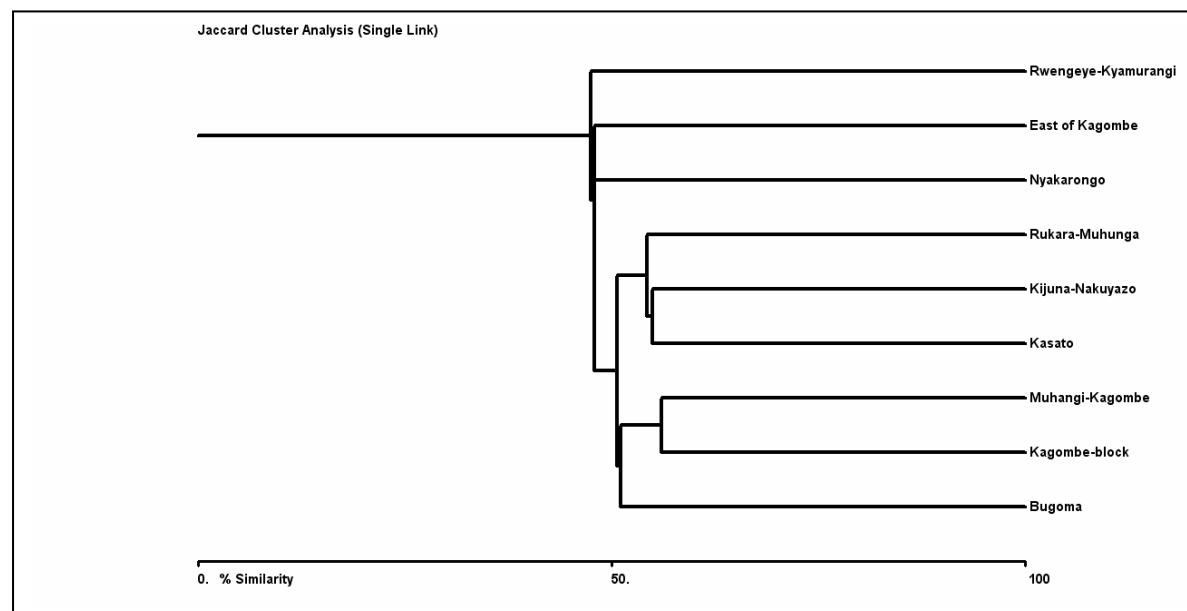


Figure 14. Jaccard cluster analysis of bird species composition in the forest blocks in the Murchison-Semliki landscape.

4.2.2. Corridor and threatened species

Those species that were considered to require the forest corridors were mapped separately (figure 15). These included the hornbills, tauracos, forest raptors (small and large), and understory species that migrate such as pittas. The majority of these observations were of tauracos and hornbills but a few raptors and green pittas (*Pitta reichenowi*) were recorded.

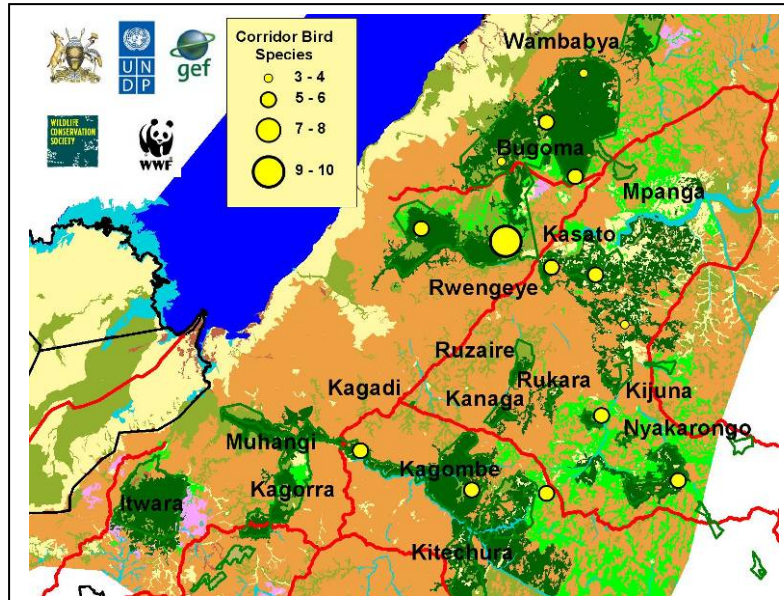


Figure 15. The relative abundance of bird species thought to require linkages between populations in the larger forest blocks (corridor species).

Species classified as threatened by IUCN (Critically endangered, endangered, vulnerable and near threatened) were identified and the number of sightings mapped per site (figure 16). These species were only found in Bugoma and Kagombe CFRs and included the endangered Nahan's francolin (*Francolinus nahani*) which was only found in Bugoma and the near threatened Grey Parrot (*Psittacus erithacus*) also seen in Bugoma and White-naped pigeon (*Columba albinucha*) seen in Kagombe CFR and a new species for this forest.

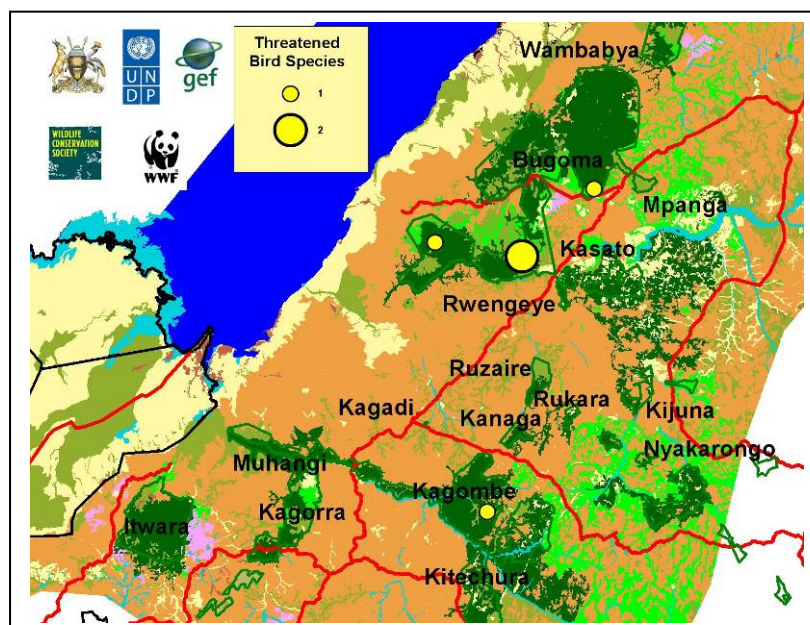


Figure 16. The locations of sightings of threatened bird species.

4.2.3. Trends in bird species

Point count surveys were made of all bird species in Bugoma Forest Reserve in August 2003. Density estimates could be calculated for the more common species as well as total species richness from both the 2003 data as well as the 2010 data as they were collected with identical methods. The surveys in 2003 focused on seven sectors that covered all of the forested portion of the forest and points were placed at 250 m intervals along reconnaissance lines that aimed to take a relatively straight direction along a compass bearing. The locations of the points do therefore differ between the two surveys. A total of 433 point counts were made in 2003 with 5,657 groups of birds encountered (13.1/point count), and 190 point counts in 2010 with 2,367 groups of birds encountered (12.5/ point count). Both surveys recorded 125 species of birds on the point counts although the combined list from both surveys was 168 species. Densities were calculated for birds with more than 50 sightings of groups of that species (table 5) using DISTANCE 6.2 and analyzing the data in fixed intervals as described in the methods in section 3.2.

Table 5. Estimated densities of the more common species of birds in Bugoma Forest Reserve in 2003 and 2010. Each species is categorized as forest specialist (FF), Forest Dependent (F) and forest edge (f) species.

Species	Density in 2003 (no/km2)	Density in 2010 (no/km2)	Z-test significance
<i>Declining species</i>			
Little Greenbul (f)	184.9	65.4	**
Western Black-headed Oriole (f)	13.9	7.4	***
Green Hylia (f)	90.3	30.7	***
Yellow-billed Barbet (FF)	9.6	14.6	**
Yellow-whiskered Greenbul (F)	143.1	20.5	***
Western Nicator (f)	116.0	17.1	**
Buff-throated Apalis (FF)	109.5	16.9	***
Yellow-throated Tinkerbird (FF)	42.6	27.1	**
Scaly-breasted Illadopsis (FF)	66.4	7.6	***
Red-tailed Bristlebill (F)	77.7	6.1	***
Rufous Flycatcher-Thrush (F)	40.5	9.3	***
Speckled Tinkerbird (F)	33.8	8.0	***
Forest Robin (F)	70.5	2.1	*
<i>Unchanging species</i>			
Olive Sunbird (F)	349.0	205.0	ns
White-spotted Flufftail (f)	4.6	4.1	ns
Hairy-breasted Barbet (f)	2.7	4.3	ns
White-thighed Hornbill (F)	22.3	10.9	ns
Yellow-rumped Tinkerbird (F)	2.9	3.3	ns
<i>Increasing species</i>			
Black-and-white Casqued Hornbill (F)	3.7	7.3	*
Black-billed Turaco (FF)	2.9	5.3	*
Tambourine Dove (f)	7.8	26.3	***

*- P<0.05; **-P<0.01; ***-P<0.001

The results show that for many of the most common species in Bugoma Forest Reserve there have been significant declines in density, some have stayed about the same and only three have increased. Why there have been such significant declines in some of the common species is unknown. There could be several explanations of which the following are some:

1. The locations of the point counts in 2010 were more evenly spread across the forest and probably included more edge habitat and grassland as a result compared to the 2003 surveys
2. The distance intervals are estimated by eye and although they were designed to be in large enough intervals that it should be relatively easy to allocate sightings accurately it is possible that some observers have estimated them incorrectly. Looking at some species the 2003 observers tended to allocate more observations to the distance intervals nearer the centre of the point. However, the fact that several species have remained stable or increased in density leads us to believe that this explanation is unlikely to be correct – if this was the cause then all species should have followed a similar trajectory.
3. It is known that in Budongo Forest there have been major changes in the phenology of the forest with significant declines in fruiting of trees over the past 20 years (Babweteera *et al.* in press). This may also be occurring in Bugoma as it is close to Budongo and this could be having significant impacts on food availability both for frugivores as well as for insects that are preyed upon by insectivorous birds.

4.3 Trees and shrubs

4.3.1. Tree and shrub species richness

A total of 199 tree and shrub species were recorded in 185 twenty metre radius plots in Bugoma and the smaller CFRs which compares with 224 recorded for Bugoma CFR (Davenport, Howard and Matthews, 1996) and 209 species recorded for Kagombe CFR (Howard and Davenport, 1996). The main block of Kagombe was not surveyed for trees and shrubs because of time and budget constraints although the corridor extension to the west towards Muhangi was surveyed. More species were found in plots in Bugoma (figure 17) than the corridor forests (small CFRs and private forests).

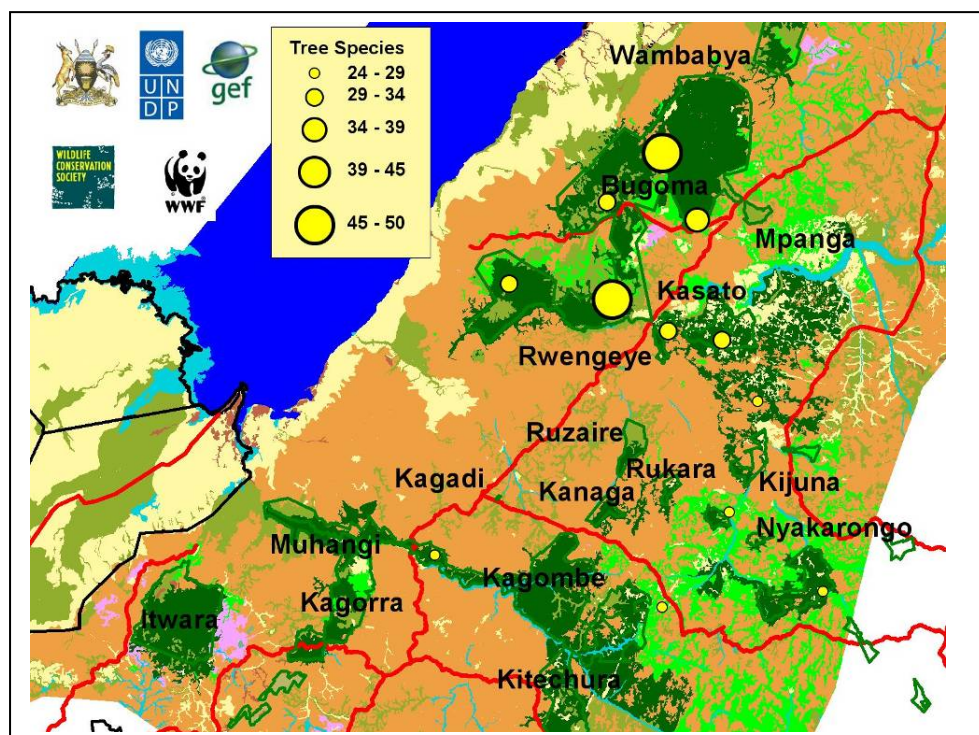


Figure 17. Relative species richness of trees and shrubs in Bugoma and the corridor forests to the south of Bugoma.

Species accumulation curves also show that Bugoma is much richer in species composition than the other forests (figure 18a). This is also true for the same forest types in Bugoma compared with the corridor forests (figure 18b). Note that this species richness is higher after sampling relatively few trees indicating that it is not simply an area effect (ie there are not more species because Bugoma is a larger forest and can contain more species – there are more species even in the same area of Bugoma as one of the smaller CFRs).

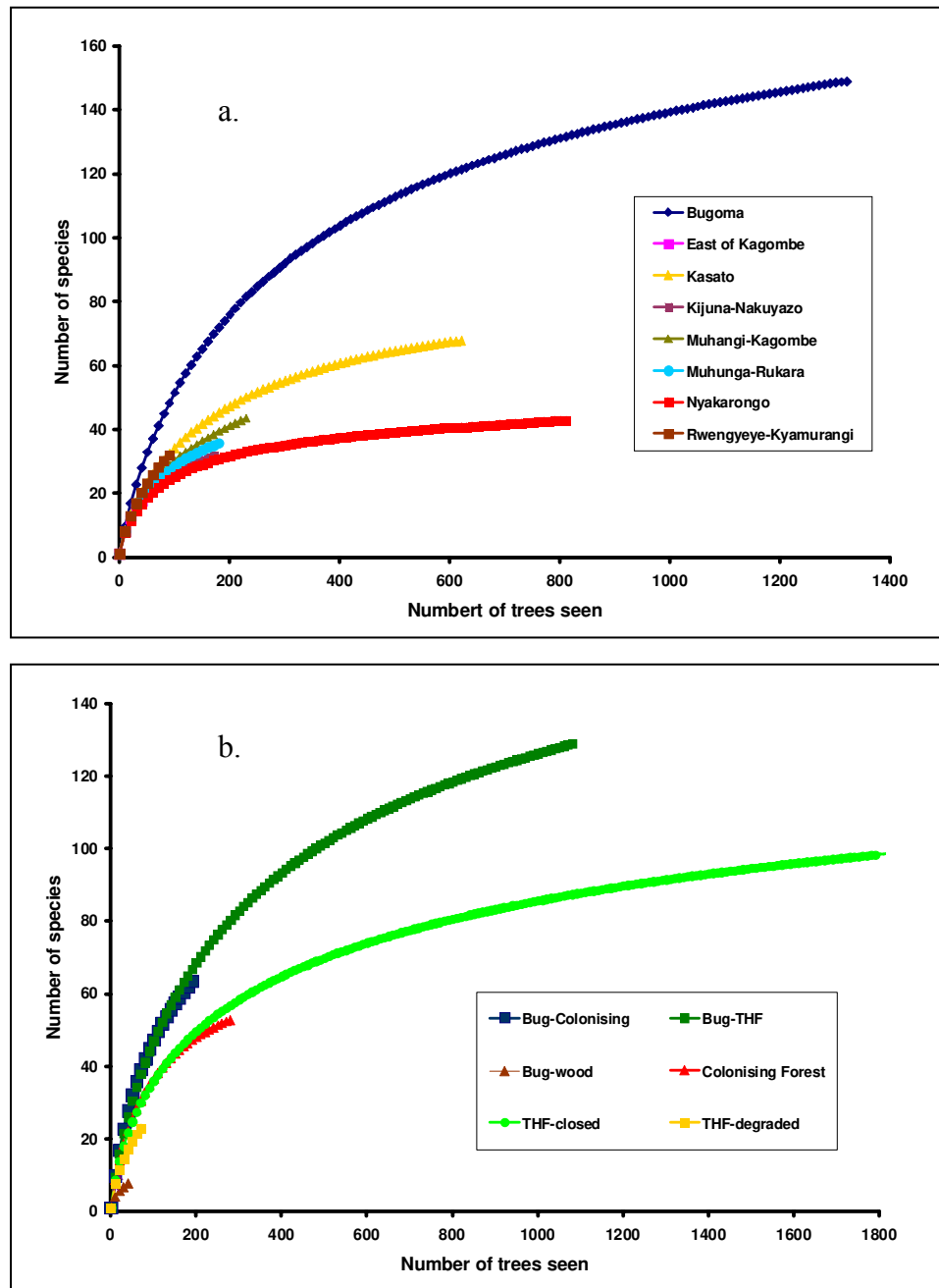


Figure 18. The rarefaction (accumulation) curves for each forest region (a), and for the same forest types in Bugoma (Bug-) and the corridor forests (b). THF – Tropical high forest.

Interestingly the species composition of Bugoma is most dissimilar to the other sites surveyed (figure 19), and it is only 26% similar to Kasato CFR and less than this for all other forest blocks in the corridor. The forest blocks in the centre of the corridor (south of Bugoma) are the most similar in species composition.

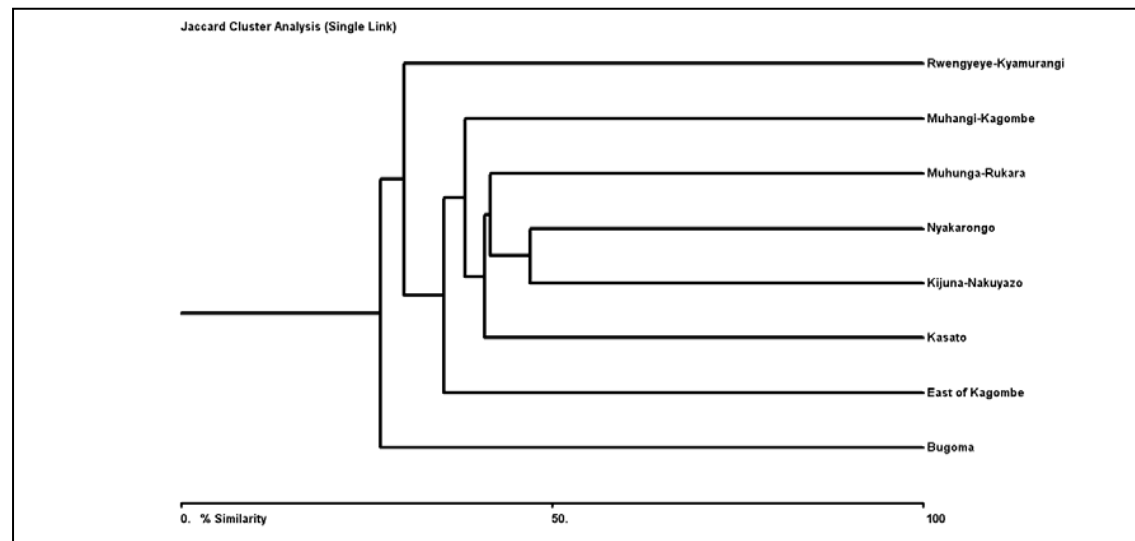


Figure 19. Cluster analysis using Jaccard's coefficient of similarity between the blocks of forest surveyed.

4.3.2. Carbon measurements

In each of the plots surveyed the diameter at breast height (DBH) was measured to obtain an estimate of the availability of carbon. Although the details of the carbon measurements and the assessment of the feasibility to obtain REDD funding for these corridors is the subject of a separate report we present here the main findings about the carbon.

Carbon was calculated using one of the more recent equations that has been suggested:

$$\text{Biomass of tree (tonnes)} = e^{(-2.9946 + 0.9317 \ln(\text{DBH}^2 \times \text{tree height}))}$$

$$\text{Biomass of CO}_2 \text{ (tonnes)} = (\text{tree biomass}/1000) \times 44/12$$

The relative abundance of carbon at the plots shows that the largest amounts are in the Bugoma CFR and the centres of Kasato and Nyakarongo CFRs (figure 20). Around the edges of these forests and in the private forests plots contained far lower amounts of carbon. On average plots across this landscape contained about 500 tonnes CO₂ per hectare. Other equations are currently being assessed as different values are obtained depending on the equation used.

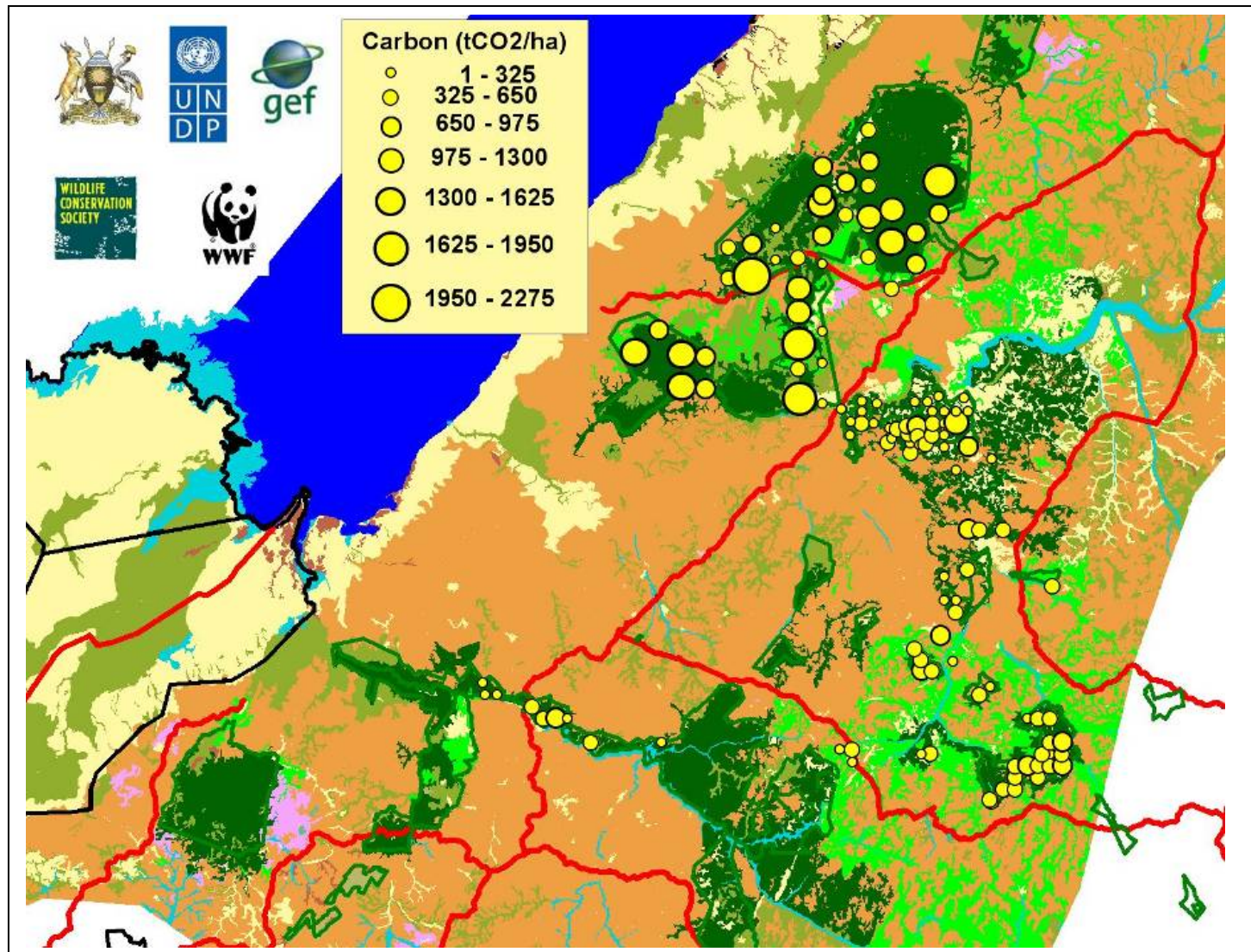


Figure 20. Estimates of the quantity of carbon per hectare at each of the 185 plots surveyed.

5.0. Trends in Biodiversity and the Conservation value of the corridor forests

This report summarises data collected on the large mammals, birds and trees in the Central Forest Reserves and connecting forest corridors on private land in Hoima, Kibaale, and Kyenjojo Districts in western Uganda. In particular it assesses the conservation value of the forests and the value of maintaining the connectivity that still remains between the forest reserves. It also assesses changes that have taken place in large mammal and bird species abundances in the larger forest blocks in the landscape. We here summarise the main findings from the results presented above.

5.1. The importance of the forest corridors for biodiversity conservation

These surveys have demonstrated that the corridor forests (both small CFRs and private forest) are of conservation value. Species richness of birds in particular is reasonably high in these forests (higher than the main forest block of Bugoma). While this is partly due to the higher numbers of edge and non-forest species in the corridor forests, in two of the CFRs (Kasato and Nyakarongo) the number of forest specialist and forest dependent species were higher than in Bugoma Forest Reserve itself. The total number of bird species found in the corridor forests was about 1/5th of the total number of species found in Uganda, indicating their conservation value.

Notable species of conservation concern using these corridors included both threatened species such as Chimpanzee, Golden cat, and White-naped Pigeon, as well as corridor species including Side-striped Jackal, Great Blue Tauraco, Black-billed Tauraco, Ross's Tauraco, Black and White Casqued Hornbill, White-thighed Hornbill, African Goshawk, African Crowned Eagle, and Little Sparrowhawk. However, none of the understorey species identified as possibly needing the corridors were found in the corridor forests, although Nahan's Francolin and Green-breasted Pitta were recorded from Bugoma Forest Reserve.

Therefore many of the species that were identified as potentially requiring connectivity between forest blocks were recorded using these corridor forests. The main exception was the understorey species group. This is likely to be due to the much greater human impact on the corridor forests leading to forest degradation. Many of the sites we visited the forest had been degraded by harvesting large trees so that the forest canopy was not intact and there was a lot of understorey vegetation. This degradation is partly reflected in the lower carbon values calculated at the plots we surveyed in the corridor forests (figure 20). Understorey species require closed canopy and shade in the understorey and rarely will cross even small gaps in the forest or openings such as those caused by roads. It will be important to monitor understorey species in future in the larger forest blocks to determine if their numbers are declining.

Few threatened species were found in these corridors, however, and their value for these species is probably limited. However, if they can provide a corridor between larger forest blocks there is a potential for these threatened species to use them to move between the larger blocks. Only one individual needs to move per generation as a general rule and therefore this doesn't have to be very frequent in long-lived species such as chimpanzees.

Human impacts in the corridor forests were high and seem to have increased significantly in Kagombe and Kasato CFRs compared with similar surveys made in 1999. This is particularly the case for timber harvesting and harvesting of building poles. Trapping of large mammals

appears to have declined which may be due to the fact more people are making money from harvesting other forest products or because large mammal numbers have declined so much that hunting is not very productive any longer. However, Bugoma CFR appears to be under better management now with much less illegal activity than in 1999.

Other CFRs were also being heavily affected by people and while the field teams were surveying many forests were in the process of being converted. Nangendo, Plumptre and Akwetaireho (2010) estimated that over 300 km² of forest had been lost in the Murchison-Semliki landscape between 2000 and 2006 and that this will have increased greatly since then. Despite this threat there are still species using these forests as corridors between different forest blocks but they are becoming increasingly isolated and fragmented.

5.2. Trends in large mammal and bird species in Bugoma and Kagombe CFR

We assessed all the available literature and data on surveys of large mammal and bird species in this landscape. The Forest Department surveys of the 1990s (Howard *et al.*, 2000) only compiled lists of species for the forests where they worked and unfortunately did not collect much quantitative data on species abundances which would have enabled some comparison with our data. Their only quantitative data was from mistnetting and the number of metre-net-hours per site were not very many which would not make comparisons very useful. We did not use mist netting in these surveys as we have found it requires a lot of effort and rarely adds species to the list for the forest if good ornithologists are employed.

We were able to evaluate trends in primate species numbers in Bugoma and Kagombe CFR and in human impacts on these forest because we were able to compare the data with similar data collected by the Wildlife Conservation Society and Jane Goodall Institute in 1999 (Plumptre *et al.* 1999). We were also able to compare common bird species densities for Bugoma CFR with surveys made by WCS in 2003 (unpublished data). The trends that were found are summarized here for these two forests:

1. Bugoma CFR appears to be in a relatively good condition at the moment despite episodes of encroachment in the 2000s and illegal logging. The encounter rates of human sign and logging/poaching activities were down from 1999 and primate numbers were stable or had increased (*Colobus guereza*). Nahan's francolin was heard in the forest and still occurs there although it was only heard at three sites in the forest. The Uganda mangabey is relatively common in the forest but did not occur in any of the forests we surveyed outside Bugoma. Elephants still can be found in the forest and probably migrate between Bugoma CFR and the Kabwoya Wildlife Reserve to the north along the Hohwa river.

Bird densities have declined greatly for many of the common species in this forest. Why this is so is not clear and it may be partially due to differences in the location of the points for the point counts between 2003 and 2010 as well as use of different observers. However the fact that some species have remained stable in density and others increased would indicate that the differences between observers are likely to be a lesser problem. It is known that ecological changes are taking place in Budongo CFR and they may well be taking place in Bugoma, but without regular monitoring it is unknown. The changes taking place in the bird populations were not related to the forest specialization of the bird (table 5) and therefore are unlikely to be due to changes in forest structure. It may be that bird populations fluctuate more than large mammals because of their higher reproductive rates. A study of savanna birds across

10 different sites in Uganda showed great changes in the relative abundances of species also despite no obvious habitat changes (Plumptre *et al.* in press).

2. Kagombe CFR was much more affected by people and human sign had increased greatly since 1999. This mostly consisted of pole cutting for building and bean stakes with some increase in timber harvesting. Chimpanzee numbers probably have declined here since 1999 although black and white colobus monkeys have increased here. No blue monkeys occurred here as observed in 1999 and very few redbellied monkeys were observed (not enough to calculate a density). Surprisingly a few elephants can still be found here despite the high human pressures and these have survived since 1999, but probably number less than 5 individuals.

The only other site where we could find trend data for forest species in the Murchison-Semliki landscape was in Budongo CFR (Babweteera *et al.* in press). These data from surveys of primates made in 1992, 1996, 2000 and 2009 estimated populations of four primate species: chimpanzee *Pan troglodytes*, blue monkey *Cercopithecus mitis*, red tail monkey *Cercopithecus ascanius*, and black and white colobus monkey *Colobus guereza*. These surveys were conducted in seven compartments that were selected to represent different forest types in the Budongo Forest.

Group densities of the monkey species remained relatively stable although in three compartments there was a significant increase in 1996. Chimpanzee density remained stable throughout the census in most compartments except Kaniyo-Pabidi (KP) where the density has increased significantly over time. The increase in KP may be linked to the habituation process of chimpanzees at this site which has increased protection of the site and also made the chimps less fearful of human presence in the forest. Encounter rates of duikers have fluctuated for many compartments. Where snare removal programs have been carried out (particularly in compartment N3) there does seem to have been a stabilization of the population of duikers and in the case of blue duikers a gradual increase in encounter rates indicating that the snare removal may have been influencing their populations.

5.3. Conclusions

The results of these surveys show that the corridor forests south of Bugoma CFR to Kagombe and Muhangi CFRs clearly are rich in biodiversity, they contain many of the species that may require connectivity to remain viable in the larger forest blocks, and they are likely to be playing a functional role in terms of connecting meta-populations of these species. There is a need to find incentives for land owners who have forest on their land in the corridors to conserve these forests in order to maintain these functional roles.

Carbon funding through the REDD+ process may provide one incentive to landowners in the corridor region to conserve forest on their land. WCS is currently working on developing a feasibility analysis for REDD+ in this region under contract to WWF with the UNDP/GEF project for the Conservation of Biodiversity in the Albertine Rift Forests of Uganda. Given the biodiversity identified during these surveys it is likely that any REDD project that aims to provide incentives to conserve the forest should be able to add a premium to the price of the carbon because of the biodiversity found here. The idea of selling carbon at a higher price for forest with high biodiversity is yet to be accepted fully but it is a concept that is currently being discussed in international fora. The survey data summarized here will be used in the REDD+ feasibility assessment that WCS to assess its potential to promote a premium to be added to the price of carbon. The carbon values found for these forests were less than the larger forest blocks but still have the potential to generate some funding. If the corridor forests could be conserved to a point where the structure of the forest recovers to a more

intact nature and the carbon biomass increased as a result then it is likely that farmers could receive significantly more funding.

These corridor forests are disappearing quickly, however, and if these findings are not acted upon soon there will be little corridor forest left to conserve and most of these species will become extinct in this region. Already many of the smaller forest reserves have been heavily encroached or degraded as we found in places such as Kagombe and Kasato CFRs. There is a need for the Ministry of Water, Energy and the Environment, the District Environmental offices and the National Forest Authority to move ahead quickly with the national REDD processes to enable these corridor forests to receive funding as soon as they can to offset the current incentives to destroy the forest for agriculture.

Acknowledgements

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